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Simulation and education

Identifying incidents of suboptimal care during paediatric emergencies–an observational study utilising in situ and simulation centre scenarios☆

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ABSTRACT

Aim: Life threatening paediatric emergencies are relatively uncommon events. When they do occur staff caring for these children must have the ability to recognise the deterioration, evaluate and simultaneously treat these patients. The aim of this study was to identify suboptimal care during standardised simulated scenarios and to identify the potential causation factors.
Methods: Participants were emergency department and operating theatre staff in Sydney, Australia. Incidents of suboptimal care were identified during scenarios and were analysed by thematic qualitative assessment methods. Potential causation factors were elicited both during and immediately after the scenarios and during facilitated debriefings. Causation factors were attributed to any of seven pre-defined categories.
Results: Seventy-three simulations occurred over 9 month period in 2011. 270 doctors, 235 nurses and 11 students participated. 194 incidents of suboptimal care were observed and attributed to 325 causation factors. There were 76 knowledge deficits, 39 clinical skill deficits, 36 leadership problems, 84 communication failures, 20 poor resource utilisations, 23 preparation and planning failures and 47 incidents of a loss of situational awareness. Clinically important themes were: paediatric life support, drug choice and doses, advanced airway and ventilation, intravenous fluids and recognition of the deteriorating patient. Recurring incidents included the failure to recognise a cardiac arrest, inadequate fluid resuscitation and incorrect medication dose administration.
Conclusions: During standardised paediatric simulations multiple incidents of suboptimal care have been identified and multiple causation factors attributed to these. Educators should use this information to adapt current training programs to encompass these factors.

1. Introduction

Life threatening paediatric emergencies are relatively uncommon events. When they do occur, staff caring for these children must have the ability to recognise the deterioration, evaluate the patient, immediately treat and obtain help for these patients. Because these emergencies are relatively uncommon, traditional bedside teaching methods with real patients often do not apply.

There is sparse information on the overall errors that occur in the care of children in emergency departments.[1] Medication errors have been reported in 39% of children attending rural emergency departments,[2] and common errors include the incorrect medication dosage (35%) and the administration of incorrect medications (30%).[3] Another study showed a 10.1% rate of prescribing errors overall with an increased risk when trainees prescribed medications and for those patients with serious illness.[4]

In the hospital setting, reported error rates vary between 1.8%–10.8% per admission, and the risk increases with the presence of chronic conditions.[5–7] Medication errors are the most common errors that occur in hospitals each year,[8] and the paediatric population may be responsible for 17% of all reported incidents, particularly in the 0–4 yrs age group.[7]

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Timely recognition and effective response to a deteriorating paediatric patient is an essential skill for all healthcare workers, with a direct effect on patient safety.[9] 'Delay and failure in treatment' and 'inappropriate or wrong treatment' may account for upto 13% of reported incidents and have been the main reason for the development of paediatric alert criteria.[7,10] In the United Kingdom the Confidential Enquiry into Maternal and Child Health (CEMACH) report 'Why Children Die' found preventable factors in 26% of reviewed cases. Common factors included difficulty in the recognition of severity of illness and poor communication.[11]

Using Simulated Learning Environments (SLEs), either in situ (in the usual environment where participants work) or within a simulation centre, enables the creation of realistic patient encounters, at a convenient time to participants and instructors, without any risk to real patients and provides a safe training environment for participants.[12,13]

Simulation Based Education (SBE) has been shown to improve patient care in a variety of settings, particularly in anaesthetics,[14–16] but evidence is still quite limited.[17,18] Utilising simulated scenarios allow facilitators to address various factors that participants may require to safely care for their patients, including knowledge, clinical skills and human factors such as leadership, communication and teamwork.[19,20] Simulation Educators require real patient information, such as incident reports and root cause analysis reports. This information can then be used to design effective SBE that can have an impact on patient care by focusing on and targeting known areas for improvement.

A recent paper by Patterson and colleagues used an in situ paediatric emergency department (ED) simulation program to uncover latent safety threats and categorised them into medication, equipment and resources issues.[21] Latent safety threats or errors are system based threats to patient safety that are previously unrecognised by providers or the organisation which can impact on the ability to provide optimal patient care.[22] Once these errors are identified it is possible to provide appropriate solutions to improve clinical management.[23]

A recent study by Lammers and colleagues demonstrated how simulation, followed immediately by debrief, can uncover underlying causes of errors in paediatric pre-hospital care. His study identified 5 key error themes: oxygen delivery, equipment organisation and use, glucose measurement, drug administration and inappropriate CPR.[1] Another paper by Cushman and colleagues has described how a discomfort and lack of familiarity with physiological differences and equipment sizes in children can lead to near misses and adverse events.[24]

The aims of this study were to identify incidents of suboptimal care during SBE scenarios and then to identify the potential causation factors for these during the debrief phase. This information could then be used to validate the appropriateness of the current programs and for the design of future SBE, demonstrating how SBE might lead to safer paediatric practice.

2. Methods

2.1. Study design

This prospective study utilised a combination of quantitative (cross sectional, observational) and qualitative research methodologies.

2.2. Setting and participants

Participants were doctors, nurses and medical and nursing students participating in the in situ SBE program in the emergency department and operating suite of the Children's Hospital at Westmead (CHW), a tertiary referral paediatric hospital in Sydney, Australia. The study also included SBE scenarios from two simulation centre courses: Paediatric Emergency Crisis Training at The Kim Oates Australian Paediatric Simulation Centre and Paediatric Emergency Medicine Crisis Management at The Sydney Clinical Skills and Simulation Centre. Participants on these two courses were ED doctors either working at CHW or other EDs in metropolitan Sydney. Standard practice for the ED in situ program was for medical staff on the night shift to observe the simulation rather than participate; those on day shift would form the team to care for the simulated patient. In situ and simulation centre scenarios were used in order to capture larger numbers of simulations during the study period. This study was approved by the Institution Ethics Committee.

2.3. Scenarios

SBE scenarios in both the in situ and centre based programs were standardised, with specific medical and nursing learning objectives, where appropriate, and part of a pre-existing established course or program and were deemed reliable and valid by expert clinical faculty. Scenarios were predominantly based on real patient conditions relevant to the paediatric ED or operating suite e.g. penetrating trauma, sick neonate, ventricular fibrillation cardiac arrest, post-operative laryngospasm and severe head injury. Scenarios were not altered for this study and participants were unaware that data was being collected other than to facilitate a standard debrief, to avoid a possible Hawthorne effect.

2.4. Study protocol

A standardised proforma was designed to capture incidents of suboptimal care and causation factors (Appendix 1). This was validated on a small initial sample, and as a result the column on severity was not completed as instructors indicated that this was not able to be determined accurately due to multiple confounding factors, including the personal interpretation of severity by the clinician instructors. Incidents of suboptimal care and potential causation factors were identified in real time during the scenarios by the clinician instructors and clarified and explored during the debriefing afterwards, with the participants. Senior clinician instructors (medical and nursing) identified the suboptimal incidents and were trained in debriefing to elicit causation factors. The majority of medical and nursing clinician instructors have completed a simulation instructor course from either the Centre for Medical Simulation (Cambridge, MA) or the Boston Children's Hospital (Boston, MA). In an attempt to reduce bias, all clinician instructors would meet after the scenario debrief and agree on the incidents of suboptimal care and causation factors. Incidents of suboptimal care were defined as incidents where there was an omission or significant delay in providing a life-saving intervention or the wrong treatment was given, in the opinion of the clinician instructors physically present during the simulation. Causation factors were attributed to one or more of seven pre-defined categories: knowledge deficit, clinical skill deficit, failure of leadership, lack of communication, poor resource utilisation, failure to anticipate and plan and lack of situational awareness amalgamated from already well described human factor principles.[25] Identifying issues with equipment availability was not an aim of this study as identifying them in a simulation centre environment would be unreliable and have little reflection on the real environment. Where participants lacked the knowledge or clinical skills to use equipment this was identified as a causation factor.

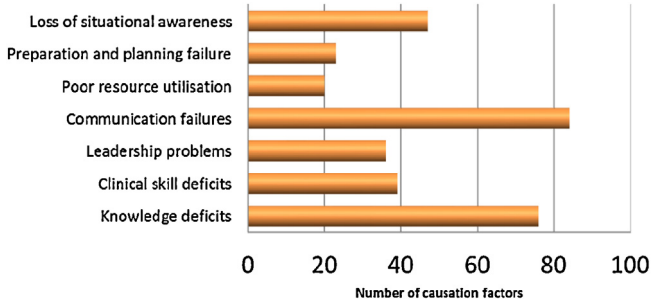

Fig. 1. Causation factors attributed to the incidents of suboptimal care.

3. Data analysis

3.1. Quantitative data was described using descriptive statistics.

Qualitative data on the incidents of suboptimal care were analysed by a subject matter expert using a thematic approach without pre-defined categories. Thematic analysis occurred at the end of the study, and the number of themes was narrowed and grouped according to frequency and clinical importance.

4. Results

Seventy-five simulations were included in the study over a period of nine months in 2011, 35 in situ in the emergency department, 20 in situ in the operating suite and 20 in the simulation centres. 270 doctors, 235 nurses and 11 medical and nursing students participated and 236 doctors, 107 nurses and 68 medical and nursing students observed the scenarios. The majority of doctors were middle grade clinicians (registrars or career medical officers) and the nurses were those usually working in either the ED or operating suite. There were 194 incidents of suboptimal care, and these were attributed by the senior clinician instructors to 325 causation factors (Fig. 1).

Thematic analysis of the incidents of sub optimal care identified five major themes, and incidents were then attributed to these themes where appropriate (Fig. 2).

5. Discussion

This study has demonstrated that during simulated paediatric emergencies there are a significant number of suboptimal events. If these events had occurred in a real patient they might have led to increased morbidity or mortality. These events have been classified according to pre-defined causation factors including knowledge, clinical skills and human factors and then thematically analysed to uncover knowledge and clinical skill gaps that may benefit future education initiatives.

Human factors are the non-technical skills necessary for effective patient care that may contributors to the suboptimal care provided in emergencies, such as attitudes, teamwork, leadership and communication skills.[9,26] This study has shown that for many suboptimal events there was a mixture of causation factors. This supports the literature suggesting that in order to successfully care for a critically ill patient clinicians need to combine knowledge, clinical skills and human factor behaviours.[27] Identifying the multifactorial causes that interplay in clinical team encounters enables us to move away from blaming individuals for individual errors but rather seeing them as a failure of the system or the team as a whole. Of the five pre-defined human factors highlighted in this study, communication failures and loss of situational awareness were identified as the primary causes of suboptimal events which were similar to previously reported data.[26,27] Team leaders became distracted by individual tasks (task focused) and lost track of the overall picture (situational awareness) resulting in the failure to detect a clinical deterioration or remain focused on team goals. Interdisciplinary team training is essential to teach staff how these factors can contribute to suboptimal care and how to mitigate against them.[23]

Thematic analysis of the qualitative data was used in this study as it allowed for an in depth examination and recognition of patterns from within the data set. The recognition of suboptimal processes identified five reoccurring themes: paediatric life support, drug choice and usage, advanced airway and ventilation, intravenous fluids and recognition of deterioration. Our study reflected similar findings to the research done by Lammers and colleagues,[1] who in their study on errors in simulated pre-hospital paediatric emergencies also identified paediatric life support and drug errors as a reoccurring theme. No equipment issues were identified. We will now discuss each of these themes in turn.

5.1. Recognition of deterioration

We have already described how a loss of situational awareness during the simulated paediatric emergency scenarios resulted in healthcare workers inability to recognise a change in the patient's condition. Changes in cardiac rhythms were not recognised, respiratory arrests went unnoticed for periods of time as well as other key changes in vital signs. These incidents led to significant delays in providing potentially lifesaving interventions. We have also identified knowledge gaps which led to a lack of recognition of deterioration, the most common being the loss of an oxygen saturation wave form on the monitor. Teams would often attribute this to the probe becoming dislodged or being disconnected rather than a loss of perfusion. This is particularly important as it may be the first indicator of an impending PEA arrest. The need for training in the detection of deterioration has already been well described by several authors and this study confirms the need in the paediatric population.[7,9,11]

5.2. Paediatric life support

It is important that all healthcare workers that care for acutely unwell children to have the knowledge, confidence and ability to respond to a collapsed child.[28] This study identified a number of suboptimal incidents involving paediatric life support in the knowledge, clinical skills and human factors categories. Incidents included a failure or delay in starting cardio pulmonary resuscitation and the incorrect management of a shockable rhythm. Ineffective chest compressions were a recurrent theme and were attributed to many of the causation factors. As effective chest compressions are the cornerstone of adequate CPR,[29] combined with efficient ventilation, we must ensure that ongoing education focuses on this factor in particular and team leaders are aware to maintain situational awareness and communication strategies to ensure its maximum effectiveness.

5.3. Drug choice and usage

Medication errors occur more frequently in paediatrics emergencies compared to adults.[8] Medication errors in the paediatric population are more likely to cause harm compared to adults.[8] The main challenge associated with paediatric medication administration is that medication dosage is based on weight and calculations are required which can lead to potential errors.[8] The majority of medication incidents identified in this study were due to knowledge gaps and prescription errors. Team members were unaware of paediatric dosing guidelines or which drugs to use for particular emergencies or procedures, e.g. rapid sequence intubation. This

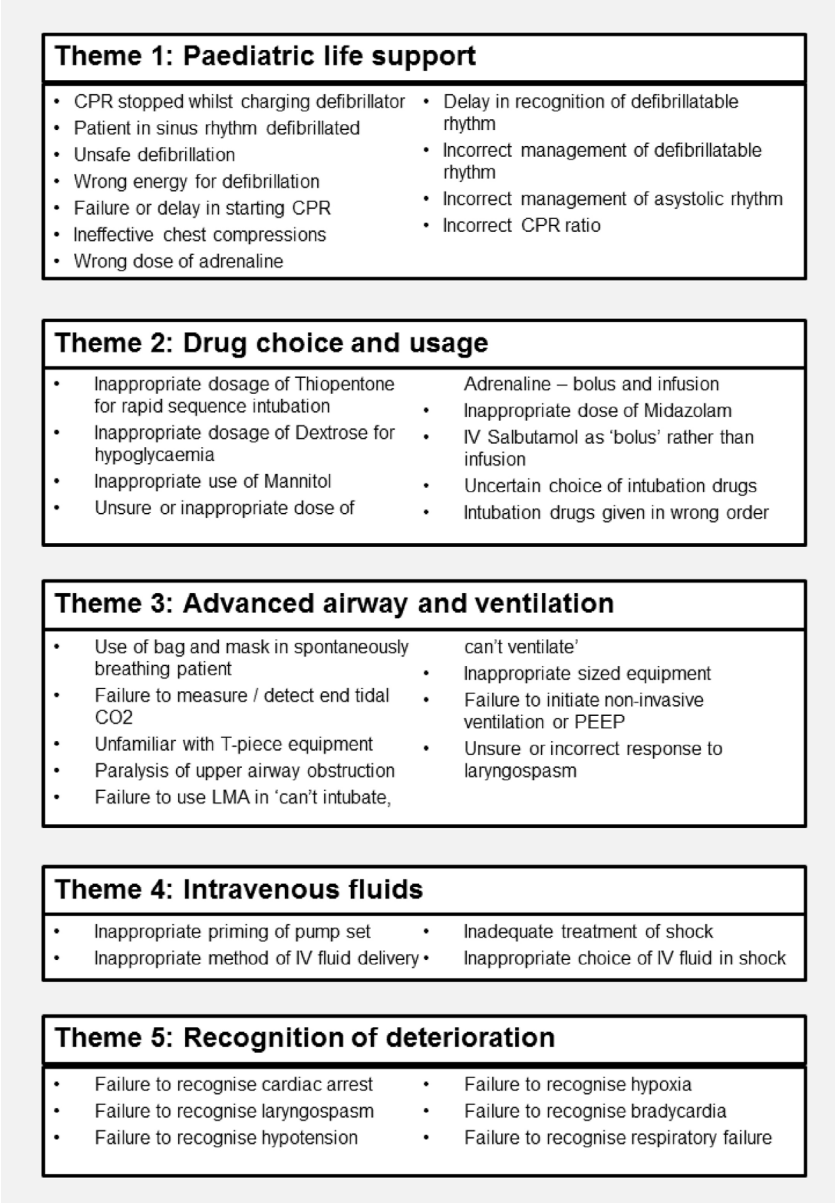

Fig. 2. A summary of the results of the thematic analysis of the incidents of suboptimal care.

emphasises that not all incidents of suboptimal care are due to human factors deficits and that staff require appropriate knowledge, skills and current resources to safely prepare and administer appropriate medications.[30] Cognitive aids such as check lists or drug calculators may help reduce these errors.[31]

5.4. Advanced airway and ventilation

Paediatric airways are different to adults due to their difference in anatomy which can provide unique challenges for healthcare workers managing a paediatric airway.[32] An important aspect of airway management in paediatrics is using the appropriate sized equipment for the individual child.[32] In a similar way to medication incidents there were several knowledge and clinical skill incidents involving the airway such as inappropriate sized equipment, lack of familiarity with the 'can't intubate, can't ventilate' algorithm and lack of familiarity with advanced airway equipment such as the T-piece. This suggests that staff, that may be required to manage paediatric airways, need further training and perhaps the use of algorithms or checklists might aid recall in an emergency situation.[33]

5.5. Intravenous fluids

Rapid administration of intravenous fluid is important in treating a hypovolemic paediatric patient.[34] Participants in the scenarios were often observed to administer fluid boluses via an infusion pump when a quicker alternative would be to utilise a syringe and three way tap or a blood pump infusion set.[34] It is important, when teaching fluid resuscitation to clarify what is meant by the term 'bolus'; not just the type of fluid but also the volume to be infused, the route of infusion and exactly how the fluid will be delivered to the patient.

Although, open to observer bias, the study methodology of using medical and nursing senior clinician instructors to identify the incidents and then collaboratively agree on attribution to causation

factors immediately after the simulations has worked well. Another methodology may have involved video recording the scenarios and retrospective review with measurement of inter-rater reliability. However, our experience suggests that senior clinicians present at the time of the scenarios have a much greater appreciation of the intricacies of the interactions than can be captured with video in the in situ environment with limited audio-visual resources.

One of the limitations with SBE is the validity of the scenario, i.e. how realistic is the patient and the environment in which the education occurs and this could be a confounder in this study. The clinicians directing the scenarios ensured that as part of the post scenario debrief analysis, events that might have been as a result of the fidelity of the simulation were excluded. The use of in situ SBE reduced the likelihood of environment and equipment fidelity issues and the use of simulations based on real patients reduced the likelihood of the simulated patient being unrealistic.

Another limitation of the study is that the incidents and causation factors identified were a function of the content of the scenarios themselves. It is unrealistic to cover every possible clinical scenario during these simulations, and hence the incidents identified here are not exhaustive over the whole paediatric emergency care curriculum

6. Conclusions

This study showed that multiple incidents of suboptimal care can be identified by using standardised paediatric simulations. Incidents of suboptimal care do not occur in isolation but rather can be attributed to multiple causation factors. The results from this study can be used by educators to influence current and new training initiatives in order to prevent the suboptimal incidents from being repeated in a real paediatric emergency.

Conflicts of interest

The authors have no conflicts of interest.

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Appendix A.

Paediatric scenario event record form
Location: Insitu □ CHW ED □ Other: _____
Lab□ KOAPSC □ SCSSC □ Other: _____
Scenario: _____ Date: _____/_____/20____
If part of a course, which course? _____
Number of participants: Doctors:_____ Nurses:_____ Med Students:_____ Nursing students:_____
Number of observers: Doctors:_____ Nurses:_____ Med Students:_____ Nursing students:_____

Event description	Reason for event						
Record nature of event, how it occurred. Contributing factors should be determined after the debrief	Knowledge deficit	Clinical skill deficit	Leadership	Communication	Resource utilisation	Anticipate and plan	Situational awareness
Example: ×10 dose iv Ad administered due to lack of knowledge by team member and lack of awareness by team leader who knew right dose. Pt into VF.	✓		✓				✓

Appendix B. Supplementary data

Supplementary material related to this article can be found, in the online version, at http://dx.doi.org/10.1016/j.resuscitation.2013.12.001.

References

1. Lammers R, Byrwa M, Fales W. Root causes of errors in a simulated prehospital pediatric emergency. Acad Emerg Med 2012;19:37–47.
2. Marcin J, Dharmar M, Cho M, Seifert L, Cook J, Cole S, et al. Medication errors among acutely ill and injured children treated in rural emergency departments. Ann Emerg Med 2007;50:361–7.
3. Selbst S, Fein J, Osterhoudt K, Ho W. Medication errors in a pediatric emergency department. Pediatr Emerg Care 1999;15:1–4.
4. Kozer E, Scolnik D, Macpherson A, Keays T, Shi K, Luk T, et al. Variables associated with medication errors in pediatric emergency medicine. Pediatrics 2002;110:737–42.
5. Ahuja N, Zhao W, Xiang H. Medical errors in US pediatric in patients with chronic conditions. Pediatrics 2012:130.
6. Slonim A, LaFleur B, Ahmed W, Joseph J. Hospital-reported medical errors in children. Pediatrics 2003:111.
7. National Patient Safety Agency. Review of patient safety for children and young people. London: National Patient Safety Agency; 2009.
8. Gonzales K. Medication administration errors and the pediatric population: a systematic search of the literature. J Pediatr Nurs 2010;25:555–65.
9. Theilen U, Leonard P, Jones P, Ardill R, Weitz J, Agrawal D, et al. Regular in situ simulation training of paediatric medical emergency team improves hospital response to deteriorating patients. Resuscitation 2012;84:218–22.
10. Chapman S, Grocott M, Franck L. Systematic review of paediatric alert criteria for identifying hospitalised children at risk of critical deterioration. Intensive Care Med 2010;36:600–11.
11. Confidential Enquiry into Maternal and Child Health. Why Children Die: the report of a pilot confidential enquiry into child death. London: CEMACH; 2006.
12. van Schaik SM, Plant J, Diane S, Tsang L, O'Sullivan P. Interprofessional team training in pediatric resuscitation: a low-cost, in situ simulation program that enhances self-efficacy among participants. Clin Pediatr 2011;50:807–15.
13. Campbell S, Wilson G, Engelhardt T. Equipment and monitoring–what is in the future to improve safety? Pediatr Anesth 2011;21:815–24.
14. Ker J, Bradley P. In: Swanwick T, editor. Simulation in medical education. Understanding medical education: evidence, theory and practice; 2010. p. 164–80.
15. Draycott TJ, Crofts JF, Ash JP, Wilson LV, Yard E, Sibanda T, et al. Improving neonatal outcome through practical shoulder dystocia training. Obstet Gynecol 2008;112:14–20.
16. Andreatta P, Saxton E, Thompson M, Annich G. Simulation-based mock codes significantly correlate with improved pediatric patient cardiopulmonary arrest survival rates. Pediatr Crit Care Med 2011;12:33–8.
17. Ross A, Kodate N, Anderson J, Thomas L, Jaye P. Review of simulation studies in anaesthesia journals, 2001–2010: mapping and content analysis. Br J Anaesth 2012;109:99–109.
18. Draycott T, Barnfield S. Surgical skills training: does it improve clinical outcome? Resuscitation 2011;82:973.
19. Shah A, Carter T, Kuwani T, Sharpe R. Simulation to develop tomorrow's medical registrar. Clin Teach 2013;10:42–6.
20. Weinberg E, Auerbach M, Shah N. The use of simulation for paediatric training and assessment. Curr Opin Paediatr 2009;21:282–7.
21. Patterson MD, Geis GL, Falcone RA, LeMaster T, Wears RL. In situ simulation: detection of safety threats and teamwork training in a high risk emergency department. BMJ Qual Saf 2013;22:468–77.
22. Alfredsdottir H, Bjornsdottir K. Nursing and patient safety in the operating room. J Adv Nurs 2008;61:29–37.
23. Garden AL, Mills SA, Wilson R, Watts P, Griffin JM, Gannon S, et al. In situ simulation training for paediatric cardiorespiratory arrest: initial observations and identification of latent errors. Anaesth Intensive Care 2010;38:1038–42.
24. Cushman JT, Fairbanks RJ, O'Gara KG, Crittenden CN, Pennington EC, Wilson MA, et al. Ambulance personnel perceptions of near misses and adverse events in pediatric patients. Prehosp Emerg Care 2010;14:477–84.
25. Ostergaard D, Dieckmann P, Lippert A. Simulation and CRM. Best Prac Res Clin Anaesthesiol 2011;25:239–49.
26. Carne B, Kennedy M, Gray T. Review article: crisis resource management in emergency medicine. Emerg Med Australas 2011;24:7–13.
27. Riem N, Boet S, Bould MD, Tavares W, Naik VN. Do technical skills correlate with non-technical skills in crisis resource management: a simulation study. Br J Anaesth 2012;109:723–8.
28. Hunt E, Fiedor-Hamilton M, Eppich W, Resuscitation Education. Narrowing the gap between evidence-based resuscitation guidelines and performance using best educational practices. Pediatr Clin North Am 2008;55:1025–50.
29. Field RA, Soar J, Davies RP, Akhtar N, Perkins GD. The impact of chest compression rates on quality of chest compressions–a manikin study. Resuscitation 2012;83:360–4.
30. Merry AF, Anderson BJ. Medication errors-new approaches to prevention. Paediatr Anaesth 2011;21:743–53.
31. Bernius M, Thibodeau B, Jones A, Clothier B, Witting M. Prevention of pediatric drug calculation errors by prehospital care providers. Prehosp Emerg Care 2008;12:486–94.
32. Soto F, Murphy A, Heaton H. Critical procedures in pediatric emergency medicine. Emerg Med Clin North Am 2013;31:335–76.
33. Hales B, Terblanche M, Fowler R, Sibbald W. Development of medical checklists for improved quality of patient care. Int J Qual Health Care 2008;20:22–30.
34. Stoner MJ, Goodman DG, Cohen DM, Fernandez SA, Hall MW. Rapid fluid resuscitation in pediatrics: testing the American College of Critical Care Medicine guideline. Ann Emerg Med 2007;50:601–7.